ZZA
Zipper Zeman Associates, Inc.
Geotechnical and Environmental Consulting

J-1960
September 23, 2004

City of Seattle – Department of Parks and Recreation
Urban Forestry Division
100 Dexter Avenue North
Seattle, Washington 98109

Attention: Mr. Mark Mead

Subject: Geotechnical Engineering Study
Proposed Vegetation Conversion
Betty Bowen Viewpoint (Marshall Park)
Seattle, Washington

Dear Mr. Mead:

Zipper Zeman Associates, Inc. (ZZA) is pleased to present herein a copy of the above-referenced report. This report presents the results of our subsurface exploration and geotechnical engineering study relative to the vegetation conversion for the proposed project. Written authorization to proceed with this study was given by Consultant Agreement No. 04-910-007, dated August 20, 2004.

The purpose of the study was to establish general surface and subsurface conditions at the site from which conclusions and recommendations regarding slope stability could be formulated. The scope of our services consisted of field explorations, laboratory testing, geotechnical engineering analysis, and preparation of this report.

The recommendations and conclusions included in this report are based on preliminary plans and the draft version of the Vegetation Management Plan provided to ZZA. Therefore, we recommend that ZZA be allowed to review the final proposed plans to verify that the conclusions and recommendations included in this report are have been properly interpreted and are appropriate for the design. This report is an instrument of service and has been prepared in accordance with generally accepted geotechnical engineering practices for the exclusive use of City of Seattle - Department Parks and Recreation and its agents, for specific application to this project and site location.

PROJECT UNDERSTANDING

We understand that the City of Seattle maintains several community viewpoints in public parks across the city. Betty Bowen Viewpoint (Marshall Park) contains two viewpoints within the park bounds. In order to maintain these viewpoints, regular vegetation maintenance in the past has been limited to pruning of the existing trees located near the western and southern property line. At the time of this report, only a Treework Proposal was available for review. This proposal is dated August 31, 2004, and was developed by the City of Seattle – Department of Park and Recreation.

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The proposed work would include major pruning (up to 50 percent height reduction) for approximately 11 trees located in the southwest corner and near the western edge of the site, falling approximately 23 trees (combination including several small Holly trees and medium Maple trees, one Cedar tree, and one Douglas Fir tree), and removal of the invasive (non-native) groundcover species, which include Himalayan Blackberry bushes and Wild Clematis ivy. We understand that this work is proposed to be completed in at least three phases, over a time period of approximately 10 years. However, annual maintenance is planned to continue as currently undertaken.

Based on the topographic data made available, we understand that the majority of the slope is over 40 percent and is classified as a steep slope to be regulated by the Environmentally Critical Areas Ordinance of the Seattle Municipal Code.

Vegetation Management Plan

We were provided with a draft copy of the *Vegetation Management for Seattle Parks Viewpoints* produced by City of Seattle - Department of Parks and Recreation. Only a draft version of this publication is available to date, and this copy is dated March of 2004. This publication sets out the Vegetation Management Plan (VMP) for maintaining each park viewpoint within the City of Seattle. The VMP for Betty Bowen Viewpoint recommends a vegetative conversion. This conversion entails a combination of tree pruning and removal, erosion control blankets before planting, planting layered vegetation on the hillside, planting a double row of low hedges at the top of the slope, mulching, and establishing irrigation. Later, annual maintenance will require physical and/or chemical removal of weeds, coppicing management of Big Leaf Maples, managing exposed soil with additional planting and erosion control matting and mulching, control of adjacent vegetation, removal of dead/declining/diseased trees, and pruning for form/shape/view.

The VMP for Betty Bowen Viewpoint indicates that approximately 40 percent of the view is currently blocked by existing vegetation. The implementation plan described in the VMP is the following:

- Phase 1: Tree removal and pruning.
- Phase 2: Eradicate invasive weeds, cover slopes with erosion control mat, plant layered vegetation, and provide temporary irrigation.
- Phase 3: Plant hedge at top of slope.

SITE DESCRIPTION

The park is located at the southwest corner of the intersection of 7th Avenue West and 8th Place West in the Queen Anne neighborhood of Seattle, Washington. The site is generally trapezoidal in shape with approximately 190 to 260 feet in the north-south direction on the east and west sides, respectively, and 130 feet in the east-west direction. A small section in the northeast corner of the site is relatively flat and grass covered. The remaining portions of the site are steeply to very steeply sloped down from east to west with a total fall across the site of over 60 vertical feet. The slope continues into the western adjacent properties, but less steep. The slope on the property ranges in inclinations from 19 to 34 degrees.

Generally, the entire site is completely covered with blackberry bushes and some sort of ivy. In the center of the slope, there are three maple stumps that appear to have resprouted and are now small maple trees. Along the western and southern property lines, there are several medium and large trees, which are mostly deciduous trees, but there are two coniferous trees along the west. Underneath a good portion of the taller trees along the southern property line are what appear to be Laurel bushes. Along the steep portion of the slope, located in the southern portion of the site, there is an existing concrete stairway that is oriented in the east-west direction. At the very southwest corner of the site, it appears that relatively new rockeries from the adjacent property extend into the park boundary. The rockeries are terraced and are approximately 6 feet in height overall.

The properties to the west and the south are generally developed with single-family residences. Most residences to the west are located at least 20 feet from their eastern property line, and some are further set-back from the property line. The residence at the western edge of the southern property line contains a concrete retaining wall that is approximately 8 feet in height above the subject site. A corrugated pipe extends onto the park property above this retaining wall that may be tied to the adjacent residence downspouts. This pipe appears to be relatively new. The rockery discussed in the previous paragraph is directly downslope of this retaining wall and pipe.

LiDAR Imagery

Topographic maps can be made using **L**ight **D**istance **A**nd **R**anging (LiDAR) imagery. We were able to view a LiDAR developed topographic map of the subject site. Because this data determines the relative elevation of the ground surface, landslide features and past grading activities can often be identified readily. Based on this information, it appears that some previous grading has occurred on the site because there appears to be a dramatic grade change mid-slope that does not appear to be consistent with surrounding topography. We have interpreted this feature as the lower extent of potential fill soil shown on *Figure 1 – Site and Exploration Plan.* Fill soil was encountered in the subsurface explorations. There does not appear to be any landslide features evident by the topographic imagery. However, this could be hidden by the previous grading and/or the dense vegetation.

SUBSURFACE CONDITIONS

The subsurface explorations completed for this study consisted of advancing two hollow-stem auger borings within the proposed vegetation conversion area. One boring was located at mid-slope and the other at the top of the slope. These locations were chosen so that a representative geologic cross-section could be developed. The borings were advanced to depths of approximately 20.5 and 35.5 feet below the existing ground surface. The approximate locations of our borings are shown on *Figure 1 - Site and Exploration Plan.* Subsurface exploration procedures and descriptive logs of our borings are enclosed in Appendix A of this report. Laboratory test procedures and results are presented in Appendix B of this report.

The borings generally encountered approximately 2.5 to 13.5 feet of loose fill soil immediately overlying loose to medium dense sand at the mid-slope and the top of the slope locations, respectively. The sand layer ranged in thickness from 2.5 to 5 feet at the top and middle of the slope, respectively. Once this soil layer was penetrated, dense to very dense, silty sand and sand with some silt was encountered. This soil stratum is glacially consolidated and commonly referred to as vashon advance outwash.

Based on the *Seattle Composite Geologic Map, Washington* by Shimel, Booth, and Troost (University of Washington, 2003), the site and vicinity is mapped as "Qva" for Vashon Advance Outwash. Advance outwash is typically a well-sorted sand and gravel deposited by ice-marginal streams that included melt-water from the surrounding advancing glacier. The "Qva" designation correlates with our subsurface exploration data, except for the fill soil encountered overlying the "Qva" soil in the borings. This deposit is typically overlain by glacial till deposits and underlain by a relatively impermeable overly-consolidated silt, often referred to as Lawton Clay. These deposits were not encountered in any of the subsurface explorations.

Soil descriptions presented in this report are based on the subsurface conditions encountered at the exploration locations, laboratory testing of recovered samples, and published geologic maps of the site vicinity. Variations in subsurface conditions may exist at other locations at the site; the nature and extent of the variations may not become evident until construction. If variations then appear, it may be necessary to reevaluate the recommendations of this report.

Groundwater Conditions

No groundwater seepage was observed in either of the subsurface explorations. Localized pockets of perched groundwater are typical in these deposits near the transition to less permeable deposits (which were not encountered within the depths of our explorations). Groundwater levels and soil moisture conditions should be expected to vary throughout the year according to season, precipitation trends, and other on- and off-site factors.

CONCLUSIONS AND RECOMMENDATIONS

The proposed project will consist of converting the existing vegetative canopy and ground cover to vegetation more conducive to maintaining the park viewpoint and vegetative species that are native to the area. Based upon the subsurface exploration program and the slope stability analyses, it is our opinion that the proposed work will not adversely impact the stability of the slope provided the following recommendations are incorporated into the final proposed scope of work. It is important to note that the existing slope is marginally stable at this time, and is subject to potential near surface sloughing. The following sections discuss our geotechnical recommendations and conclusions in the anticipated sequence of the project.

Slope Stability Analysis

In order to evaluate the stability of the existing slope, we completed several slope stability analyses using the XSTABL computer program. This program was developed by Interactive Software Designs, Inc.. Our stability analyses evaluated the stability of a representative cross-section of the steep western-facing slope during all phases of the proposed work. It is our opinion, based on the encountered soil conditions, inclination and height of the slope, type of vegetation cover, and proposed tree removal, that this section is representative of the overall slope stability and can be used to determine potential adverse impacts to the slope due to the proposed vegetation conversion. This form of analysis only considers an actual mass movement type of slope failure because the computer model is incapable of evaluating erosion potential of the surface of the slope. Erosion potential is discussed in the **Erosion Control** section of this report.

Our analysis of the existing slope configuration evaluated both static and pseudo-static (seismic) conditions. The USGS Seismic Hazard Mapping Project earthquake hazard map for the area indicats a peak horizontal ground acceleration (a_{max}) of 0.33g for an earthquake with a 10 percent exceedance in 50 years (Richter Magnitude of approximately 7). Our analysis used a pseudo-static horizontal coefficient (k_h) of 0.16g. Using approximately half of the maximum value is a commonly accepted standard of practice since the engineering means of evaluating the stability of a slope is generally unidirectional and not three-dimensional.

Existing Canopy Vegetation

As discussed in the sections above, the only canopy vegetation currently existing onsite is the Bigleaf Maples along the western and southern property lines with two coniferous trees in the center of the western property line. Some small trees consisting of Holly and Laurel are located along the southern property line. These types of vegetation perform two essential functions in regards to slope stability. The first is that they provide erosion prevention by preventing water from reaching the ground surface as well as the root structure soaking up water that infiltrates the ground surface. Second, the root structure provides an increase in shear strength to the soil. This strength increase varies depending on the depth and type of the roots and is typically accounted for as a direct increase to the cohesion of the soil.

Based on the type of the vegetation existing on the slope, we have attributed 100 pounds per square foot (psf) strength increase to the top one foot of soil in the area of the network of large trees. This strength increase is based on engineering judgement and data provided in *Biotechnical and Soil Bioengineering Slope Stabilization, Chapter 3 (Gray and Solir, 1996)*. This data suggests that over 300 psf strength increase is possible in well-established root systems and to depths much greater than one foot in sandy soils. However, it is our opinion, that since no data is available on the root mass per volume of soil, the lower limits should be used, especially since the analysis is for comparison and not stabilization type analysis.

Existing Understory Vegetation

Currently, there is minimal understory vegetation at the site. During our site visit, we observed several Laurel and Holly trees located near the western and southern property lines underneath the taller deciduous trees. This type of understory vegetation also provides some additional strength to the soil and erosion prevention similar to the canopy vegetation. Based on the same literature (Gray and Solir, 1996), it is our opinion that extensive vegetation of this type would likely contribute an increase to the shear strength of approximately 50 psf. However, since this type of vegetation is currently only located sporadically across the site and is intertwined with the larger trees, no contribution to the soil strength was used in the existing slope configuration because it is already accounted for with the canopy vegetation increase. However, for a final slope condition, the strength increase of 50 psf was attributed to the top one foot of soil since there should be well-established understory type vegetation.

Existing Ground Cover Vegetation

Currently, the site contains approximately 95 to 100 percent ground surface coverage by ground cover type vegetation. However, according to the Department of Parks and Recreation, the majority of this vegetation is invasive (Blackberry bushes and Wild Clematis ivy). These types of vegetation have very shallow root systems, and, therefore, essentially do not provide any increase to the soil strength. However, these types of vegetation are essential in prevention of surface erosion and are discussed in more detail in the section entitled **Erosion Control**. Nonetheless, it is our opinion that no increase to the soil strength can be attributed to the existing ground cover vegetation.

Geologic Cross Section

Based on our review of the subsurface explorations completed at the site for the geotechnical components of this project, one generalized subsurface soil and groundwater profile through the steep western-facing slope was developed to model the existing site conditions. *Figure 1 – Site and Exploration Plan* shows the location of the geologic cross-section. As discussed above, certain vegetation types have some contributions to the soil strength values and have been accounted for in the cross-section.

This cross-section consisted of loose, fill soil overlying loose to medium dense sand. The depth of the fill soil is approximately 2.5 feet near boring B-1 and expands to 13 feet near boring B-2. The medium dense sand thickness was estimated to be approximately 7 feet near boring B-1 and 2.5 feet near boring B-2. Dense to very dense sand with some silt was modeled at a depth of 7.5 and 16 feet below the existing ground surface near boring B-1 and B-2, respectively. The remainder of the transition between soil strata were extrapolated at nearly a straight line beyond these two points. The slope of the underlying strata were assumed based on the existing slopes and the interpreted transitions encountered in the borings. Based on the subsurface exploration data and the existing site conditions, it is our opinion that this model is a reasonable approximation of the subsurface conditions within the proposed vegetation conversion at the site.

Our geologic cross-section does not contain any groundwater elements within the profile. No groundwater was encountered in any of the explorations, and due to the granular nature of the soils encountered, it is our opinion that no perched groundwater should be included in the slope modeling. In addition, it is our opinion that the site soils are granular enough that a saturated or perched seepage condition would not take place in any of the phases of work.

Based on relative density, grain size distributions, depositional history, site specific boring data, and engineering judgement, we estimated strength values for each stratum described above. The fill soils were estimated to have a friction angle of 32 degrees with a cohesion of 24 psf. These values were back-calculated to obtain a minimum factor of safety of 1.0 for a pseudo-static horizontal acceleration of 0.08g (approximating the 2001 Nisqually earthquake). The medium dense sand strength values were estimated to be a friction angle of 35 degrees and a cohesion of 0 psf. The very dense, silty sand strength was estimated to have a friction angle of 40 degrees and a cohesion of 0 psf. It is our opinion that these above-referenced friction and cohesion values are reasonable estimates of the fill soil, medium dense sand, and very dense, silty sand strength parameters.

Analysis

Using a random circular failure surface analysis based on the simplified Bishop method, we analyzed this particular slope's stability both under static and pseudo-static conditions for each phase of proposed work. As the attached results of the computer analysis show (Appendix C), the critical failure surfaces generally occur upslope of the portion of the slope vegetated with the medium to tall trees. This is generally due to the increase in soil shear strength attributed to the roots. Also, the failure surfaces are relatively shallow, extending at most 2 to 3 feet below the existing ground surface with safety factors around 1.2 for the static conditions and less than one for the design earthquake conditions. Deeper failures would result in higher factors of safety.

Based on the results of the existing slope analysis, it is our opinion that the slope is marginally stable in regards to near surface sloughing or thin landslides. The safety factor of 1.2 for the static condition is less than typical design standards (approximately 1.5), and the seismic safety factor of 0.87 indicates instability during a large earthquake.

Post Phase 1 and Phase 2

Work phases 1 and 2 were combined because no change to strength values occur due to pruning or removing of trees. These phases of work, as described above, include tree pruning and removal, invasive species removal, immediate placement of the erosion control mat, and planting of new trees and slope vegetation. The reason for this assumption is that although some of the trees will be cut to the ground, the stumps will remain. As is evident onsite, the Maple trees continue to grow and resprout. Therefore, the contribution of shear strength from the roots would still contribute to the stability of the slope. Only two trees will be removed that typically tend to decay as a result of falling. We understand that it is typical to leave the trunks of the trees removed staked in place along the slope and have accounted for this in placing a surcharge of 15 psf on the face of the lower portion of the slope and a 2.5 psf surcharge for the erosion control blanket.

The results of the analysis are a static safety factor of 1.2 and a seismic safety factor of 0.88. Based on these results, it is our opinion that this phase of work will not adversely impact the stability of the slope provided that the work is performed in general accordance with our recommendations discussed below.

Post Phase 3 (Final Vegetation Conversion)

The final state of the slope was analyzed as post Phase 3, which is generally once the planted vegetation has been established. The results of the analysis were a static and seismic safety factors of 1.22 and 0.9, respectively. Therefore, it appears that there will be a slight increase to the stability of the slope. This increase may actually be greater than the analyses show because we have used the lower limits of the strength increases due to the new vegetation root systems. Based on these results, it is our opinion that the overall work of the project will not adversely impact the stability of the slope, and, in fact, the new vegetation could potentially add near surface stability due to the deeper root development.

Tree Pruning / Removal

There are several benefits and adverse effects of trees in regards to the stability steep slopes. Some of the benefits of trees have been discussed earlier in this report and include increase to near surface slope stability and erosion prevention. However, some of the adverse impacts also threaten adjacent property owners. Among the adverse effects are *surcharging* and *windthrowing*. Each of these adds to the driving forces of a potential slide and are difficult to account for in stability analyses due to the high variability. *Windthowing* essentially transfers wind loads on the tree to the ground and *surcharging* means that the added weight of the tree decreases the stability. Each of these adverse effects will be reduced due to the proposed pruning and/or removal.

Another risk of trees on steep slopes is the potential for trees to become projectiles. It was shown in the stability analysis that the current stability of the slope is marginal in the static condition and generally unstable in an earthquake condition. Therefore, there is a potential for these trees to become projectiles in the event of a landslide causing significant damage to downslope structures in their path. In addition, fallen trees have this same potential. Therefore, we recommend that the fallen trees be cut into lengths no greater than 8 feet before being staked to the ground. Also, no trunks should be placed on slopes steeper than 50 percent (2H:1V), which limits the area to the lower half of the slope (as shown in the slope stability analysis).

The proposed tree pruning and removal work is planned to be part of the first phase of work. Several species are planned to be removed and include a Douglas Fir, a Cedar, several Hollies, several Maples, and a Laurel. For the most part, these trees are currently contributing the existing stability of the slope because of their root structure. With the exception of the Douglas Fir and the Cedar, these root systems will continue to provide the same contribution to the stability. The root systems of the Douglas Fir and Cedar, because they are coniferous trees, will eventually decay, and will no longer contribute to the stability of the slope. Therefore, it is important that new trees be planted around the area of the fallen Douglas Fir and Cedar trees, to make up for the potential loss of strength.

Erosion Control

The existing ground cover vegetation and canopy vegetation currently provide a natural erosion control cover. If the vegetation were to be removed as proposed, without providing a substitute erosion control measure, rutting and massive sediment transport to the downslope adjacent properties would occur during times of wet weather and irrigating. Therefore, in order to prevent substantial erosion, temporary erosion control blankets and possibly plastic will need to be used during the proposed conversion. The blankets and/or plastic should be placed as soon as possible following removal of the existing invasive vegetation. This work should also be scheduled during the drier summer months to also limit erosion potential.

The universal soil loss equation (USLE) is typically used to estimate surface erosion potential. The equation is as follows:

$A = R*K*L*S*C*P$;
where: A = soil loss per acre (tons)
R = rainfall factor
K = soil erodibility value
L = slope length factor
S = slope inclination factor
C = vegetation factor
P = erosion control practice factor

Essentially, for each phase of work and the existing condition, the majority of the values remain the same. Therefore, we are mostly concerned about the vegetation factor. We estimate that the existing ground cover vegetation may have a Vegetation Factor 'C' as low as 0.011 during the summer time months and may increase to 0.09 in the winter when the ground cover dies back or becomes dormant (a higher factor correlates to a greater soil loss). These values are based on Table 2-5 (Gray and Solir, 1996). Therefore, as long as the temporary cases remain at below these values, no adverse impact to adjacent properties will result in regards to soil erosion.

Based on these assumptions, we recommend that an erosion control blanket having similar or better properties than *GEOCOIR/DeKowe 900* be placed along the entire slope. This blanket should be placed in accordance with the manufacturer's specifications. In addition to the erosion control blanket, at least 3 inches of mulch, but not more than 6 inches, should be placed prior to placing the blanket. In addition, certain coverage standards for each growing season should be set as minimums for growth coverage or more planting would be necessary because the erosion control blanket has a functional longevity of approximately 5 years. It is our opinion that this erosion control method would adequately prevent soil erosion from exceeding current conditions.

Understory / Ground Cover Planting

The understory and ground cover planting should immediately follow the placement of the erosion control blankets and should be scheduled such that very little or no irrigation will be necessary to establish growth. The minimum coverage requirements set out in the VMP are adequate, in our opinion. However, the VMP does not set out types of vegetation to be planted specifically. It is our opinion that for the vegetation conversion to be most beneficial to the slope, the species planted should be woody, evergreen bushes in addition to a ground cover type of vegetation. The bushes should be medium-sized once in their mature age. These species should be native to the climate region. In other words, the vegetation should be able to withstand the drier summer months without irrigation in the long-term and thrive in the wet winter months. The medium bushes would provide a slight increase to the stability of the near surface soils while the ground cover would provide long-term erosion control.

Irrigation

Irrigation on steep slopes is a widely debated topic when discussing potential impacts to a particular slope. The site soils are generally granular in nature and would allow an excessive amount of rainfall or irrigation to infiltrate before a saturated soil condition developed, but great care should be taken when planning to irrigate on steep slopes. If irrigation is going to be installed for this project, we recommend that the following recommendations be a minimum guide and not as an exhaustive list of guidelines.

The main concern with irrigation systems on steep slopes is the potential for a failure of a sprinkler or break in the line, subsequently inundating the slope with water. In order to prevent this, we recommend that the irrigation system consist of rubber hoses with sprinkler heads staked to the ground surface. Also, the irrigation system should be human controlled, by this we mean that a person has to physically plug-in and unplug the sprinkler system to water the vegetation. In addition to the physical shut-off, we recommend that irrigation be limited to no more than 1.5 inches of total water per week (including precipitation). The irrigating should also be limited to May through October. By following these minimum guidelines, the chance of a major sediment transport to adjacent properties will be mitigated.

CLOSURE

The conclusions and recommendations presented in this report are based on the explorations accomplished for this study. The location and depth of the explorations for this study was completed within the site and scope constraints of the project so as to yield the information necessary to formulate our conclusions and recommendations. Should changes to the project be made that are not consistent with the assumptions stated in this report, we recommend that we be allowed to review these changes and modify our recommendations accordingly.

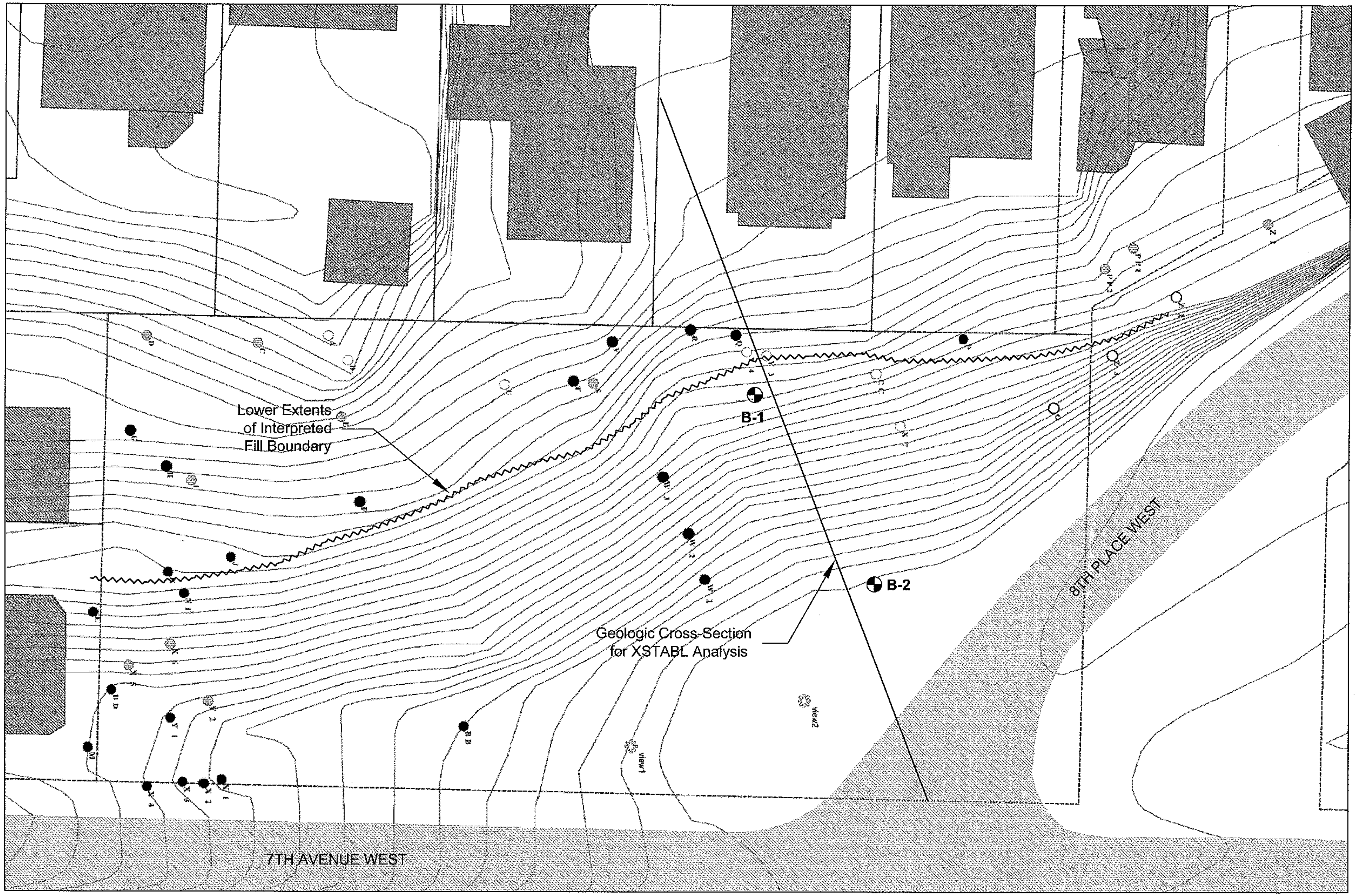
We also recommend that ZZA review the construction documents to confirm that our geotechnical engineering recommendations have been properly interpreted and implemented in the design. We appreciate this opportunity to be of service to you, and would be pleased to discuss the contents of this report or other aspects of the project with you at your convenience.

Respectfully submitted,
Zipper Zeman Associates, Inc.

Kristopher T. Hauck
Staff Engineer

John E. Zipper, P.E.
President

Enclosures: Figure 1 – Site and Exploration Plan
Appendix A – Field Exploration Procedures and Logs
Appendix B – Laboratory Testing Procedures and Results
Appendix C – Slope Stability Analysis (XSTABL Output)



LEGEND:

B-1 — BORING NUMBER AND APPROXIMATE LOCATION

LEGEND FROM BASEMAP:

TREE HEIGHT REDUCTION

- 0%
- 1- 49%
- 100%
- Buildings
- 2ft LIDAR derived contours
- Parcels

0 30 60
APPROXIMATE SCALE IN FEET

Zipper Zeman Associates, Inc.	Project No: J-1960	Betty Bowen Viewpoint (Marshall Park)
Geotechnical and Environmental Consulting	Drawn by: K. Hauck	Seattle, Washington
18905 - 33rd Avenue West, Suite 117	Date: Sept. 2004	**FIGURE 1 - SITE AND EXPLORATION PLAN**
Lynnwood, Washington 98036	Scale: As Noted	Basemap PDF File Provided by City of Seattle - Department of Parks and Recreation, altered by ZZA.
Tele: (425) 771-3304 Fax: (425) 771-3549		

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APPENDIX A

FIELD EXPLORATION PROCEDURES AND LOGS

APPENDIX A
FIELD EXPLORATION PROCEDURES AND LOGS
J-1960

Our field exploration for this project included two borings advanced on August 24, 2004. Approximate exploration locations are shown on the Site and Exploration Plan, Figure 1. Exploration locations were determined field visual observations relative to a topographic map of the site, dated August 31, 2004, prepared by City of Seattle – Department of Parks and Recreation. As such, the exploration locations should be considered accurate to the degree implied by the measurement method. The approximate ground surface elevation at each exploration location was determined by interpolating the information provided on the topographic plan. The approximate location of the borings is shown of *Figure 1 – Site and Exploration Plan.* The following sections describe our procedures associated with the exploration. Descriptive logs of the explorations are enclosed in this appendix.

Soil Boring Procedures

Our exploratory borings were advanced with a hollow stem auger, using a portable drill rig operated by an independent drilling firm working under subcontract to our firm. A geotechnical engineer from our firm continuously observed the borings, logged the subsurface conditions encountered, and obtained representative soil samples. All samples were stored in moisture-tight containers and transported to our laboratory for further visual classification and testing. After each boring was completed, the borehole was backfilled with soil cuttings and bentonite clay.

Throughout the drilling operation, soil samples were obtained at 2.5- to 5-foot depth intervals by means of the Standard Penetration Test (ASTM: D-1586). This testing and sampling procedure consists of driving a standard 2-inch outside diameter steel split spoon sampler 18 inches into the soil with a 140-pound hammer free falling 30 inches. The number of blows required to drive the sampler through each 6-inch interval is recorded, and the total number of blows struck during the final 12 inches is recorded as the Standard Penetration Resistance, or "blow count" (N value). If a total of 50 blows is struck within any 6-inch interval, the driving is stopped and the blow count is recorded as 50 blows for the actual penetration distance. The resulting Standard Penetration Resistance values indicate the relative density of granular soils and the relative consistency of cohesive soils.

The enclosed boring logs describe the vertical sequence of soils and materials encountered in each boring, based primarily upon our field classifications and supported by our subsequent laboratory examination and testing. Where a soil contact was observed to be gradational, our logs indicate the average contact depth. Where a soil type changed between sample intervals, we inferred the contact depth. Our logs also graphically indicate the blow count, sample type, sample number, and approximate depth of each soil sample obtained from the boring, as well as any laboratory tests performed on these soil samples. If any groundwater was encountered in a borehole, the approximate groundwater depth, and date of observation, is depicted on the log. Groundwater depth estimates are typically based on the moisture content of soil samples, the wetted portion of the drilling rods, the water level measured in the borehole after the auger has been extracted, or through the use of an observation well.

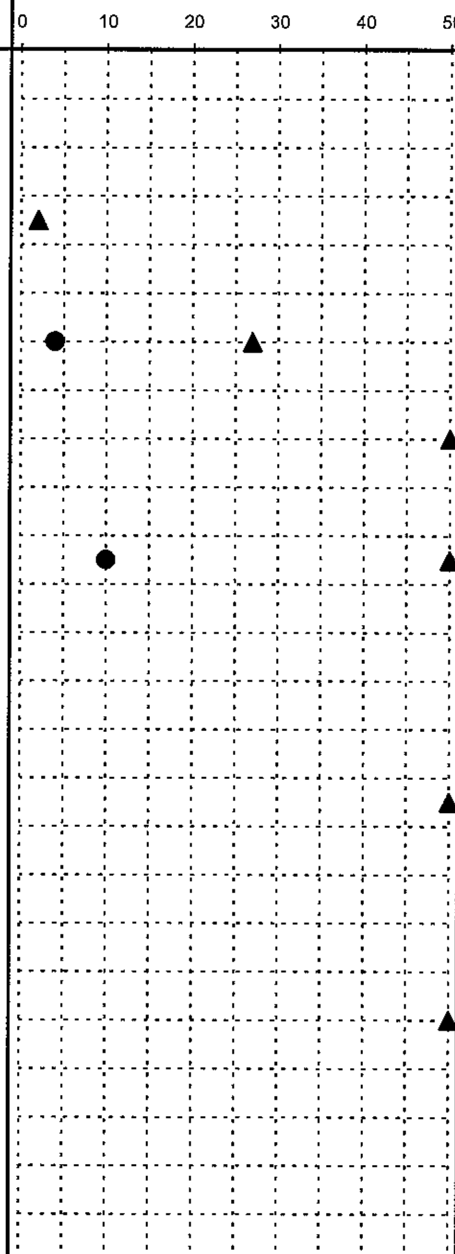
The boring logs presented in this appendix are based upon the drilling action, observation of the samples secured, laboratory test results, and field logs. The various types of soils are indicated as well as the depth where the soils or characteristics of the soils changed. It should be noted that these changes may have been gradual, and if the changes occurred between samples intervals, they were inferred.

PROJECT: Betty Bowen Park	JOB NO.: J-1960	BORING: B-1	PAGE 1 OF 1
Location: Seattle, Washington	Approximate Elevation: Middle of Slope		

Depth (ft)	Soil Description	Sample Type	Sample Number	Ground Water	N-values	Testing
0	Grass over Loose, very moist, black, organic, silty SAND with abundant concrete debris (Fill)					
	Loose, damp, red-brown, gravelly, fine SAND, some silt	2-inch O.D. split spoon	1		2	
5	Medium-dense, damp, tan, gravelly, medium to fine SAND, some silt	2-inch O.D. split spoon	2		27	GSA
	Very dense, damp, tan-brown, gravelly, medium to fine SAND, some silt	2-inch O.D. split spoon	3		50/6"	
10	grades to medium SAND, some silt, moist	2-inch O.D. split spoon	4		50/4"	GSA
15	grades to some gravel	2-inch O.D. split spoon	5		50/4"	
20		2-inch O.D. split spoon	6		50/5"	
	Boring terminated at 20.5 feet on 8/24/2004 No groundwater was encountered during drilling. No caving was encountered during drilling.					
25						

Penetration Resistance

▲ Standard — Blows per foot — △ Other



Explanation

- 2-inch O.D. split spoon sample
- 3-inch I.D Shelby tube sample
- ⊗ No Recovery
- ▼ ATD Groundwater level at time of drilling or date of measurement

Monitoring Well Key

- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing

Moisture Content

Plastic Limit — Natural — Liquid Limit

Testing Key

GSA = Grain Size Analysis
200W = 200 Wash Analysis
Att. = Atterberg Limits
Consol. = Consolidation Test

ZZA Zipper Zeman Associates, Inc. Geotechnical and Environmental Consulting	BORING LOG	Figure A-1
	Date Drilled: 8/24/04	Logged By: KTH

PROJECT: Betty Bowen Park	**JOB NO.:** J-1960	**BORING:** B-2	**PAGE 1 OF 2**
Location: Seattle, Washington	**Approximate Elevation:** Top of Slope		

Depth (ft)	Soil Description	Sample Type	Sample Number	Ground Water	N-values	Testing
0	Grass over					
	Loose to medium-dense, damp, tan, gravelly, silty SAND, trace organics (Fill)	I	1		12	
5	Loose, damp to moist, tan, silty, medium to fine SAND, some and gravel (Fill)	I	2		5	
	grades to silty, fine SAND, some gravel (Fill)	I	3		8	GSA
10		I	4		6	
	grades to gravelly, silty SAND (Fill)	I	5		10	
	Medium dense, damp, tan-orange, silty, fine SAND, trace gravel					
15		I	6		29	
	Dense, damp to moist, tan-gray, silty, medium to fine SAND, some gravel	No Recovery	7		42	
20		No Recovery	8		59	
	grades to silty, medium SAND, some gravel, very dense	I	9		57	GSA
25						

Penetration Resistance: ▲ Standard, △ Other; Blows per foot 0 10 20 30 40 50

Explanation

- 2-inch O.D. split spoon sample
- 3-inch I.D Shelby tube sample
- No Recovery
- Groundwater level at time of drilling or date of measurement (ATD)

Monitoring Well Key

- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing

Moisture Content

Plastic Limit — Natural — Liquid Limit

Testing Key

GSA = Grain Size Analysis
200W = 200 Wash Analysis
Att. = Atterberg Limits
Consol. = Consolidation Test

ZZA Zipper Zeman Associates, Inc. Geotechnical and Environmental Consulting	**BORING LOG**	**Figure A-2**
	Date Drilled: 8/24/04	**Logged By: KTH**

PROJECT: Betty Bowen Park	JOB NO.: J-1960	BORING: B-2	PAGE 2 OF 2
Location: Seattle, Washington	Approximate Elevation: Top of Slope		

Depth (ft)	Soil Description	Sample Type	Sample Number	Ground Water	Penetration Resistance (▲ Standard, △ Other; Blows per foot 0–50)	N-values	Testing
25	Very dense, moist to very moist, tan-gray, silty, medium SAND, trace gravel	I	10		● ~15; ▲ 50	50/6"	
30		I	11		▲ 50	50/5"	
35	grades to gravelly, medium SAND	I	12		▲ 50	50/5"	
	Boring terminated at 35.5 feet on 8/24/2004. No groundwater was encountered during drilling. No caving was encountered during drilling.						
40							
45							
50							

Explanation

- I — 2-inch O.D. split spoon sample
- II — 3-inch I.D Shelby tube sample
- ⊗ — No Recovery
- ▼ ATD — Groundwater level at time of drilling or date of measurement

Monitoring Well Key

- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing

Moisture Content

Plastic Limit — Natural — Liquid Limit

Testing Key

GSA = Grain Size Analysis
200W = 200 Wash Analysis
Att. = Atterberg Limits
Consol. = Consolidation Test

APPENDIX B

LABORATORY TESTING PROCEDURES AND RESULTS

APPENDIX B
LABORATORY TESTING PROCEDURES
J-1960

A series of laboratory tests were performed during the course of this study to evaluate the index and geotechnical engineering properties of the subsurface soils. Descriptions of the types of tests performed are given below.

Visual Classification

Samples recovered from the exploration locations were visually classified in the field during the exploration program. Representative portions of the samples were carefully packaged in moisture tight containers and transported to our laboratory where the field classifications were verified or modified as required. Visual classification was generally done in accordance with the Unified Soil Classification system. Visual soil classification includes evaluation of color, relative moisture content, soil type based upon grain size, and accessory soil types included in the sample. Soil classifications are presented on the exploration logs in Appendix A.

Moisture Content Determinations

Moisture content determinations were performed on representative samples obtained from the exploration in order to aid in identification and correlation of soil types. The determinations were made in general accordance with the test procedures described in ASTM: D-2216. The test results are shown on the exploration logs in Appendix A.

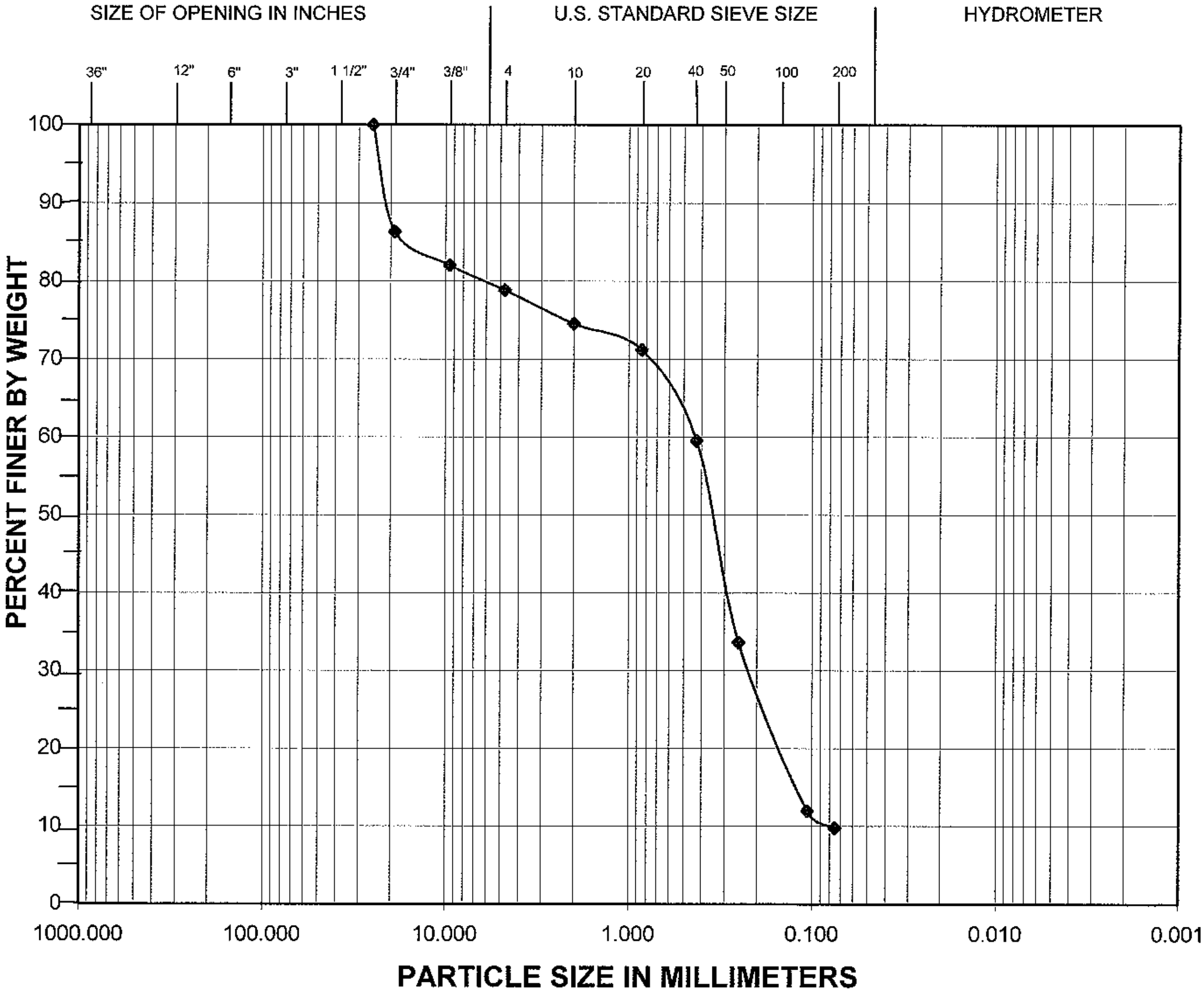
Grain Size Analysis

A grain size analysis indicates the range in diameter of soil particles included in a particular sample. Grain size analyses were performed on representative samples in general accordance with ASTM: D-422. The results of the grain size determinations for the samples were used in classification of the soils, and are presented in this appendix.

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 1140



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

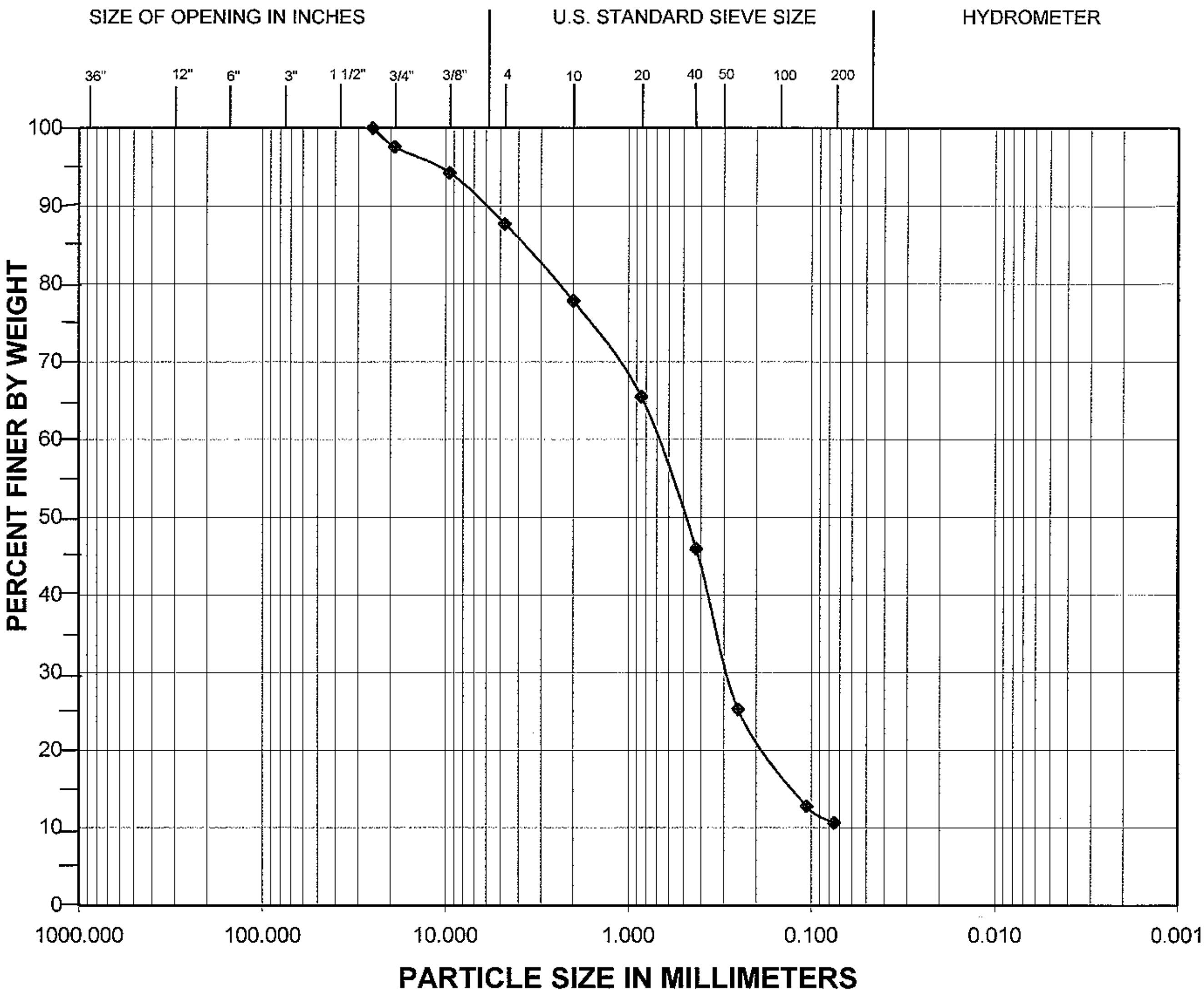
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-1	S-2		4	9.8	gravelly SAND with some silt

Zipper Zeman Associates, Inc. Geotechnical and Environmental Consulting	PROJECT NO: J-1960 DATE OF TESTING:	PROJECT NAME: Betty Bowen Park

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 1140



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

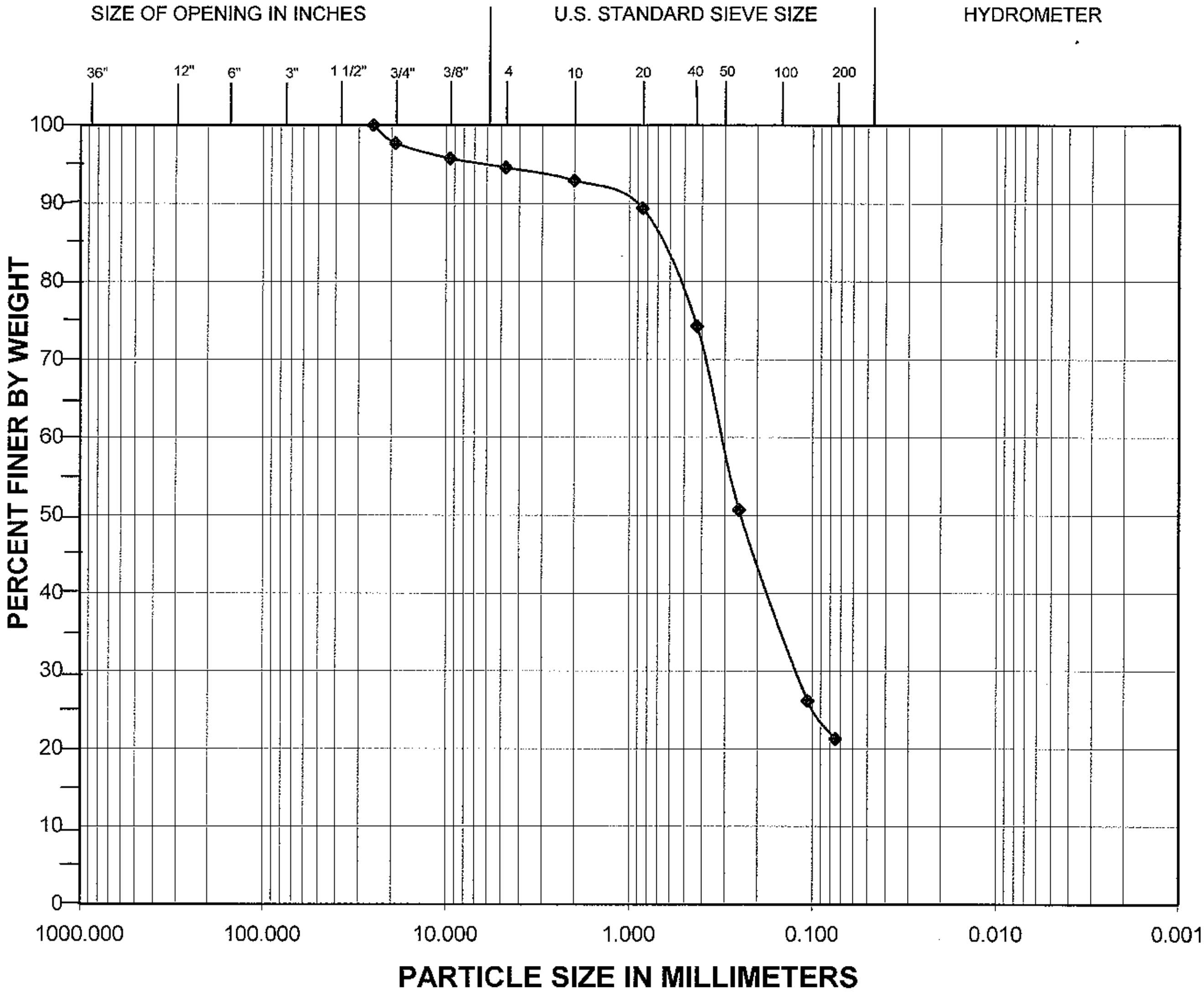
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-1	S-4		10	10.6	gravelly SAND with some silt

Zipper Zeman Associates, Inc. Geotechnical and Environmental Consulting	PROJECT NO: J-1960 DATE OF TESTING:	PROJECT NAME: Betty Bowen Park

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 1140



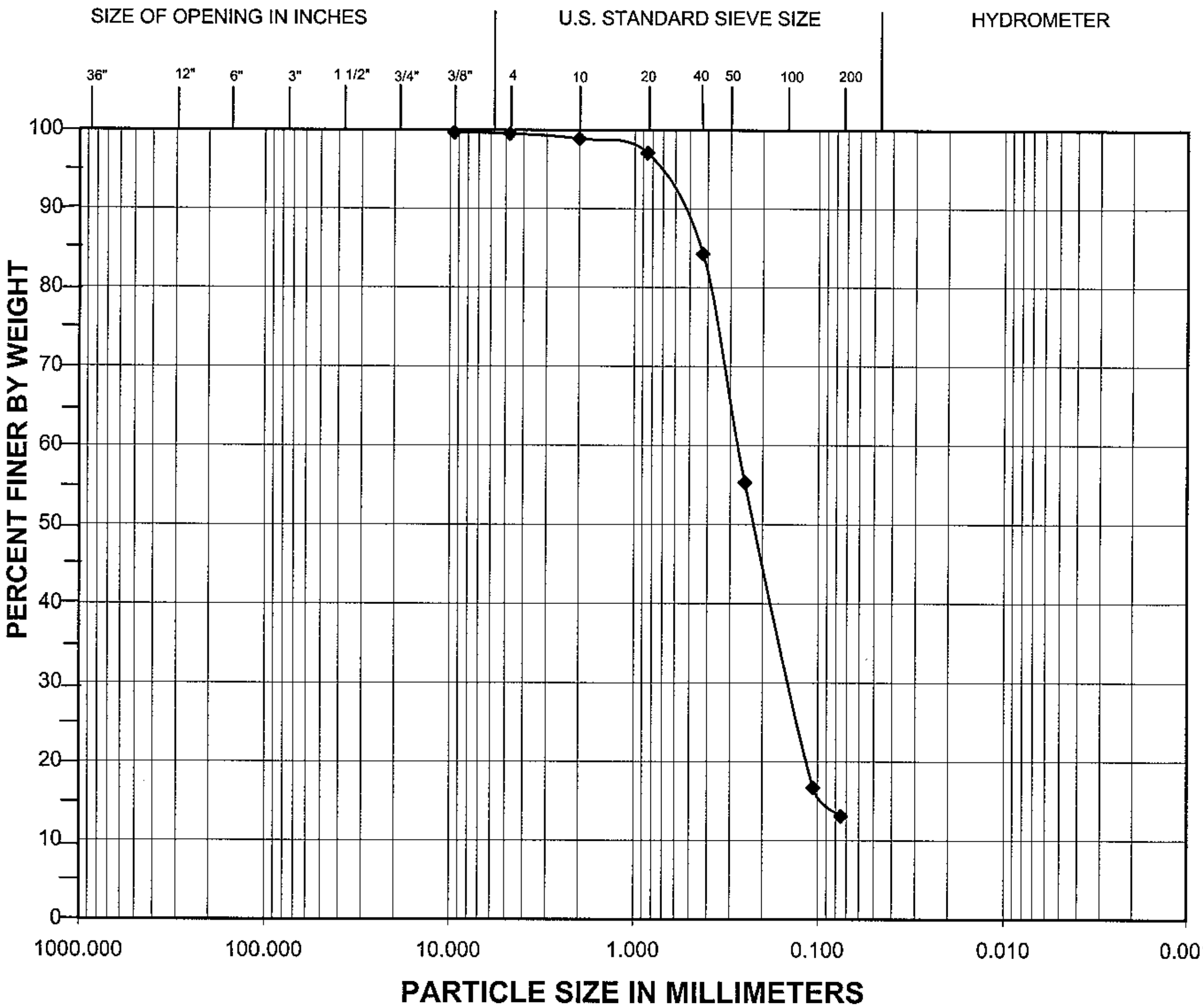
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-2	S-3		8	21.3	silty SAND with some gravel

Zipper Zeman Associates, Inc. Geotechnical and Environmental Consulting	PROJECT NO: J-1960 DATE OF TESTING:	PROJECT NAME: Betty Bowen Park

GRAIN SIZE ANALYSIS Test Results Summary ASTM D 1140



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

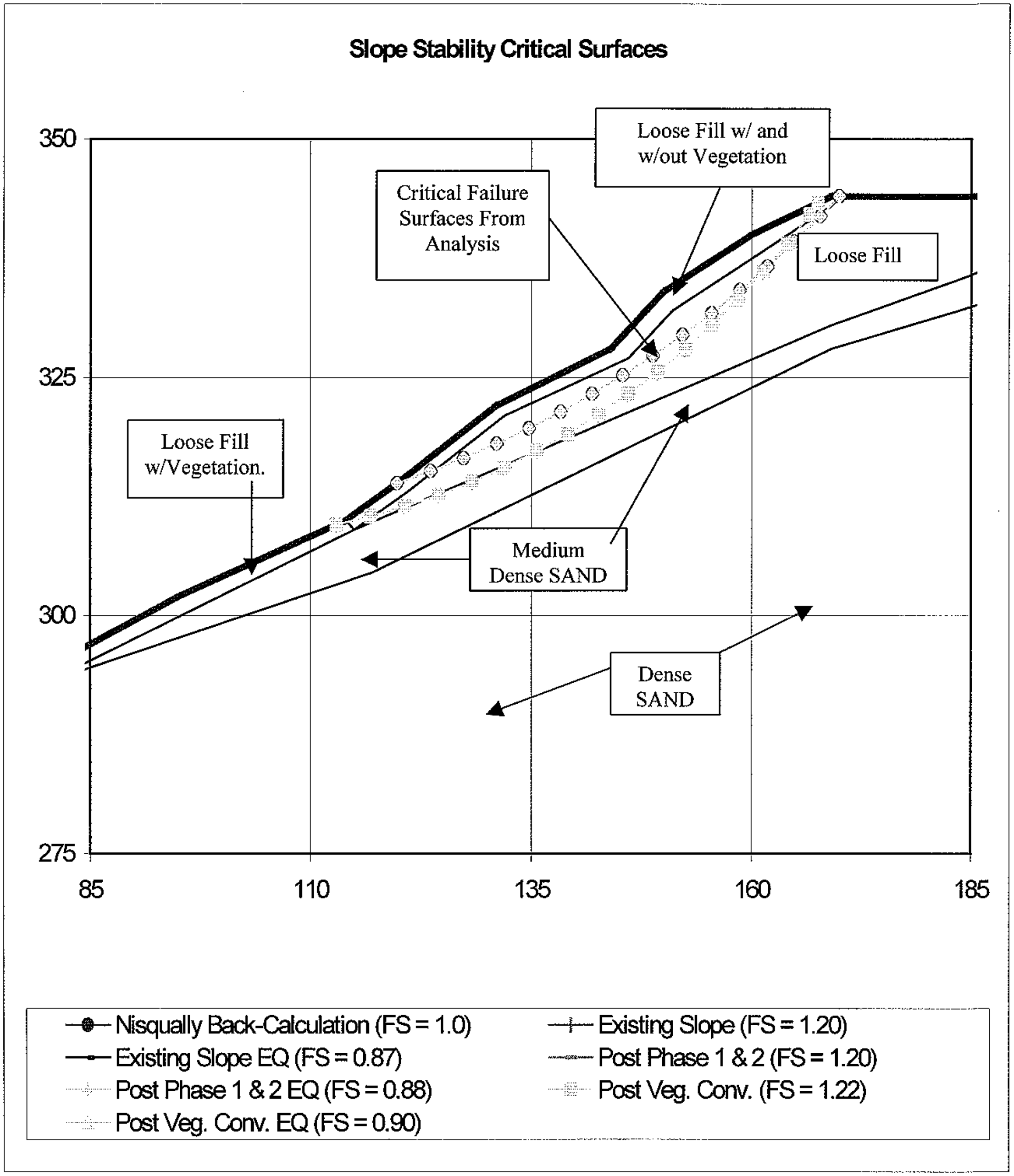
Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-2	S-9		15	13.1	silty SAND with trace gravel

Zipper Zeman Associates, Inc. Geotechnical and Environmental Consulting	PROJECT NO: J-1960 DATE OF TESTING:	PROJECT NAME: Betty Bowen Park

APPENDIX C

SLOPE STABILITY ANALYSES (XSTABL OUTPUT)



Slope Stability Critical Surfaces
350
325
300
275
85
110
135
160
185
Loose Fill w/ and w/out Vegetation
Critical Failure Surfaces From Analysis
Loose Fill
Loose Fill w/Vegetation.
Medium Dense SAND
Dense SAND
Nisqually Back-Calculation (FS = 1.0)
Existing Slope (FS = 1.20)
Existing Slope EQ (FS = 0.87)
Post Phase 1 & 2 (FS = 1.20)
Post Phase 1 & 2 EQ (FS = 0.88)
Post Veg. Conv. (FS = 1.22)
Post Veg. Conv. EQ (FS = 0.90)

XSTABL File: J1960NIS 9-10-** 16:33

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****************************************
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*                                      *
*       Slope Stability Analysis       *
*             using the                *
*          Method of Slices            *
*                                      *
*        Copyright (C) 1992 - 98       *
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*       Moscow, ID 83843, U.S.A.       *
*                                      *
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*                                      *
*  Ver. 5.202               96 Ä 1692  *
****************************************
```

Problem Description : Betty Bowen Existing Nisqually

SEGMENT BOUNDARY COORDINATES

16 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	286.0	22.0	288.0	3
2	22.0	288.0	55.0	290.0	3
3	55.0	290.0	74.0	292.0	3
4	74.0	292.0	79.0	294.0	3
5	79.0	294.0	95.0	302.0	1
6	95.0	302.0	114.0	310.0	1
7	114.0	310.0	117.0	312.0	2
8	117.0	312.0	120.0	314.0	2
9	120.0	314.0	131.0	322.0	2
10	131.0	322.0	144.0	328.0	2
11	144.0	328.0	150.0	334.0	2
12	150.0	334.0	160.0	340.0	2
13	160.0	340.0	169.0	344.0	2
14	169.0	344.0	170.0	344.0	2
15	170.0	344.0	210.0	344.0	2
16	210.0	344.0	227.0	344.0	3

15 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	114.0	310.0	115.0	309.0	1
2	79.0	294.0	80.0	293.0	3
3	80.0	293.0	115.0	309.0	3
4	115.0	309.0	121.0	313.0	2
5	121.0	313.0	132.0	321.0	2
6	132.0	321.0	146.0	327.0	2

7	146.0	327.0	151.0	332.0	2
8	151.0	332.0	169.0	343.0	2
9	169.0	343.0	170.0	344.0	2
10	115.0	309.0	169.0	330.5	3
11	169.0	330.5	210.0	344.0	3
12	.0	275.0	80.0	293.0	4
13	80.0	293.0	117.0	304.5	4
14	117.0	304.5	169.0	328.0	4
15	169.0	328.0	227.0	344.0	4

ISOTROPIC Soil Parameters
----

4 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	100.0	105.0	124.0	32.00	.000	.0	0
2	100.0	105.0	24.0	32.00	.000	.0	0
3	110.0	110.0	.0	35.00	.000	.0	0
4	125.0	125.0	.0	40.00	.000	.0	0

A horizontal earthquake loading coefficient
of .080 has been assigned

A vertical earthquake loading coefficient
of .000 has been assigned

A critical failure surface searching method, using a random
technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced
along the ground surface between x = 75.0 ft
and x = 125.0 ft

Each surface terminates between x = 130.0 ft
and x = 220.0 ft

Unless further limitations were imposed, the minimum elevation
at which a surface extends is y = .0 ft

4.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined
within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

****
-- WARNING -- WARNING -- WARNING -- WARNING -- (# 48)

****
Negative effective stresses were calculated at the base of a slice.
This warning is usually reported for cases where slices have low self
weight and a relatively high "c" shear strength parameter. In such
cases, this effect can only be eliminated by reducing the "c" value.

****

USER SELECTED option for unrestricted values of strength

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface
is specified by 16 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	119.83	313.89
2	123.62	315.15
3	127.38	316.53
4	131.08	318.03
5	134.74	319.65
6	138.34	321.39
7	141.89	323.24
8	145.37	325.20
9	148.79	327.28
10	152.15	329.46
11	155.43	331.75
12	158.63	334.14
13	161.76	336.64
14	164.80	339.23
15	167.77	341.92
16	169.91	344.00

**** Simplified BISHOP FOS = 1.017 ****

The following is a summary of the TEN most critical surfaces

Problem Description : Betty Bowen Existing Nisqually

	FOS	Circle Center		Radius	Initial	Terminal	Resisting
	(BISHOP)	x-coord	y-coord		x-coord	x-coord	Moment
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft-lb)
1.	1.017	82.34	432.98	124.85	119.83	169.91	1.367E+06
2.	1.017	94.92	399.64	91.87	112.93	167.49	1.513E+06
3.	1.035	99.25	396.21	84.09	121.55	162.90	6.490E+05
4.	1.039	86.99	407.70	99.93	118.10	160.81	7.069E+05
5.	1.048	91.29	401.59	95.25	109.48	166.18	1.580E+06
6.	1.050	103.38	391.01	77.23	123.28	162.18	5.232E+05
7.	1.057	44.76	518.16	219.17	114.66	177.81	4.201E+06
8.	1.064	88.40	411.26	106.08	106.03	170.44	2.363E+06
9.	1.068	96.37	426.19	114.73	119.83	176.40	2.280E+06
10.	1.074	109.31	365.39	53.38	118.10	154.18	4.094E+05

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XSTABL File: J1960EX   9-10-**   16:34

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*              X S T A B L             *
*                                      *
*        Slope Stability Analysis      *
*              using the               *
*           Method of Slices           *
*                                      *
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*         Moscow, ID 83843, U.S.A.     *
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*                                      *
*  Ver. 5.202              96 Ä 1692   *
****************************************
```

Problem Description : Betty Bowen Existing Vegetation

SEGMENT BOUNDARY COORDINATES

16 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	286.0	22.0	288.0	3
2	22.0	288.0	55.0	290.0	3
3	55.0	290.0	74.0	292.0	3
4	74.0	292.0	79.0	294.0	3
5	79.0	294.0	95.0	302.0	1
6	95.0	302.0	114.0	310.0	1
7	114.0	310.0	117.0	312.0	2
8	117.0	312.0	120.0	314.0	2
9	120.0	314.0	131.0	322.0	2
10	131.0	322.0	144.0	328.0	2
11	144.0	328.0	150.0	334.0	2
12	150.0	334.0	160.0	340.0	2
13	160.0	340.0	169.0	344.0	2
14	169.0	344.0	170.0	344.0	2
15	170.0	344.0	210.0	344.0	2
16	210.0	344.0	227.0	344.0	3

15 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	114.0	310.0	115.0	309.0	1
2	79.0	294.0	80.0	293.0	3
3	80.0	293.0	115.0	309.0	3
4	115.0	309.0	121.0	313.0	2
5	121.0	313.0	132.0	321.0	2
6	132.0	321.0	146.0	327.0	2

7	146.0	327.0	151.0	332.0	2
8	151.0	332.0	169.0	343.0	2
9	169.0	343.0	170.0	344.0	2
10	115.0	309.0	169.0	330.5	3
11	169.0	330.5	210.0	344.0	3
12	.0	275.0	80.0	293.0	4
13	80.0	293.0	117.0	304.5	4
14	117.0	304.5	169.0	328.0	4
15	169.0	328.0	227.0	344.0	4

ISOTROPIC Soil Parameters
----

4 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	100.0	105.0	124.0	32.00	.000	.0	0
2	100.0	105.0	24.0	32.00	.000	.0	0
3	110.0	110.0	.0	35.00	.000	.0	0
4	125.0	125.0	.0	40.00	.000	.0	0

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 75.0 ft
and x = 125.0 ft

Each surface terminates between x = 130.0 ft
and x = 220.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

4.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

****
-- WARNING -- WARNING -- WARNING -- WARNING -- (# 48)

****

Negative effective stresses were calculated at the base of a slice.

This warning is usually reported for cases where slices have low self weight and a relatively high "c" shear strength parameter. In such cases, this effect can only be eliminated by reducing the "c" value.

****

USER SELECTED option for unrestricted values of strength

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface is specified by 18 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	112.93	309.55
2	116.84	310.42
3	120.70	311.46
4	124.51	312.66
5	128.27	314.03
6	131.96	315.57
7	135.59	317.26
8	139.14	319.11
9	142.60	321.11
10	145.97	323.26
11	149.25	325.55
12	152.42	327.99
13	155.49	330.56
14	158.44	333.26
15	161.27	336.09
16	163.97	339.04
17	166.54	342.10
18	167.49	343.33

**** Simplified BISHOP FOS = 1.195 ****

The following is a summary of the TEN most critical surfaces

Problem Description : Betty Bowen Existing Vegetation

FOS	Circle Center		Radius	Initial	Terminal	Resisting
(BISHOP)	x-coord	y-coord		x-coord	x-coord	Moment

		(ft)	(ft)	(ft)	(ft)	(ft)	(ft-lb)
1.	1.195	94.92	399.64	91.87	112.93	167.49	1.577E+06
2.	1.198	82.34	432.98	124.85	119.83	169.91	1.426E+06
3.	1.213	99.25	396.21	84.09	121.55	162.90	6.763E+05
4.	1.218	86.99	407.70	99.93	118.10	160.81	7.367E+05
5.	1.229	91.29	401.59	95.25	109.48	166.18	1.645E+06
6.	1.230	103.38	391.01	77.23	123.28	162.18	5.448E+05
7.	1.251	88.40	411.26	106.08	106.03	170.44	2.460E+06
8.	1.253	110.21	341.36	31.24	114.66	136.45	1.190E+05
9.	1.258	44.76	518.16	219.17	114.66	177.81	4.371E+06
10.	1.260	109.98	380.08	64.22	125.00	160.20	3.764E+05

* * * END OF FILE * * *

XSTABL File: J1960EXQ   9-10-**   16:35

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****************************************
*              X S T A B L             *
*                                      *
*        Slope Stability Analysis      *
*               using the              *
*            Method of Slices          *
*                                      *
*         Copyright (C) 1992 - 98      *
*   Interactive Software Designs, Inc. *
*        Moscow, ID 83843, U.S.A.      *
*                                      *
*          All Rights Reserved         *
*                                      *
*  Ver. 5.202              96 Ä 1692   *
****************************************
```

Problem Description : Betty Bowen Existing Design Quake

SEGMENT BOUNDARY COORDINATES

----

16 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	286.0	22.0	288.0	3
2	22.0	288.0	55.0	290.0	3
3	55.0	290.0	74.0	292.0	3
4	74.0	292.0	79.0	294.0	3
5	79.0	294.0	95.0	302.0	1
6	95.0	302.0	114.0	310.0	1
7	114.0	310.0	117.0	312.0	2
8	117.0	312.0	120.0	314.0	2
9	120.0	314.0	131.0	322.0	2
10	131.0	322.0	144.0	328.0	2
11	144.0	328.0	150.0	334.0	2
12	150.0	334.0	160.0	340.0	2
13	160.0	340.0	169.0	344.0	2
14	169.0	344.0	170.0	344.0	2
15	170.0	344.0	210.0	344.0	2
16	210.0	344.0	227.0	344.0	3

15 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	114.0	310.0	115.0	309.0	1
2	79.0	294.0	80.0	293.0	3
3	80.0	293.0	115.0	309.0	3
4	115.0	309.0	121.0	313.0	2
5	121.0	313.0	132.0	321.0	2
6	132.0	321.0	146.0	327.0	2
7	146.0	327.0	151.0	332.0	2

8	151.0	332.0	169.0	343.0	2
9	169.0	343.0	170.0	344.0	2
10	115.0	309.0	169.0	330.5	3
11	169.0	330.5	210.0	344.0	3
12	.0	275.0	80.0	293.0	4
13	80.0	293.0	117.0	304.5	4
14	117.0	304.5	169.0	328.0	4
15	169.0	328.0	227.0	344.0	4

ISOTROPIC Soil Parameters
----

4 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	100.0	105.0	124.0	32.00	.000	.0	0
2	100.0	105.0	24.0	32.00	.000	.0	0
3	110.0	110.0	.0	35.00	.000	.0	0
4	125.0	125.0	.0	40.00	.000	.0	0

A horizontal earthquake loading coefficient
of .160 has been assigned

A vertical earthquake loading coefficient
of .000 has been assigned

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 75.0 ft
and x = 125.0 ft

Each surface terminates between x = 130.0 ft
and x = 220.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

4.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

****
-- WARNING -- WARNING -- WARNING -- WARNING -- (# 48)

****
Negative effective stresses were calculated at the base of a slice.
This warning is usually reported for cases where slices have low self
weight and a relatively high "c" shear strength parameter. In such
cases, this effect can only be eliminated by reducing the "c" value.

****

USER SELECTED option for unrestricted values of strength

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface
is specified by 16 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	119.83	313.89
2	123.62	315.15
3	127.38	316.53
4	131.08	318.03
5	134.74	319.65
6	138.34	321.39
7	141.89	323.24
8	145.37	325.20
9	148.79	327.28
10	152.15	329.46
11	155.43	331.75
12	158.63	334.14
13	161.76	336.64
14	164.80	339.23
15	167.77	341.92
16	169.91	344.00

**** Simplified BISHOP FOS = .874 ****

The following is a summary of the TEN most critical surfaces

Problem Description : Betty Bowen Existing Design Quake

FOS Circle Center Radius Initial Terminal
Resisting

	(BISHOP)	x-coord	y-coord		x-coord	x-coord	Moment
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft-lb)
1.	.874	82.34	432.98	124.85	119.83	169.91	1.310E+06
2.	.876	94.92	399.64	91.87	112.93	167.49	1.448E+06
3.	.892	99.25	396.21	84.09	121.55	162.90	6.218E+05
4.	.895	86.99	407.70	99.93	118.10	160.81	6.771E+05
5.	.901	44.76	518.16	219.17	114.66	177.81	4.030E+06
6.	.904	91.29	401.59	95.25	109.48	166.18	1.516E+06
7.	.905	103.38	391.01	77.23	123.28	162.18	5.016E+05
8.	.913	96.37	426.19	114.73	119.83	176.40	2.190E+06
9.	.917	88.40	411.26	106.08	106.03	170.44	2.268E+06
10.	.917	65.37	487.21	182.88	116.38	179.10	3.726E+06

* * * END OF FILE * * *

XSTABL File: J19601   9-10-**   16:39

```
****************************************
*              X S T A B L             *
*                                      *
*       Slope Stability Analysis       *
*              using the               *
*           Method of Slices           *
*                                      *
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****************************************
```

Problem Description : Betty Bowen Prune/Remove and EC Mat

SEGMENT BOUNDARY COORDINATES

16 SURFACE boundary segments

Segment

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below
1	.0	286.0	22.0	288.0	3
2	22.0	288.0	55.0	290.0	3
3	55.0	290.0	74.0	292.0	3
4	74.0	292.0	79.0	294.0	3
5	79.0	294.0	95.0	302.0	1
6	95.0	302.0	114.0	310.0	1
7	114.0	310.0	117.0	312.0	2
8	117.0	312.0	120.0	314.0	2
9	120.0	314.0	131.0	322.0	2
10	131.0	322.0	144.0	328.0	2
11	144.0	328.0	150.0	334.0	2
12	150.0	334.0	160.0	340.0	2
13	160.0	340.0	169.0	344.0	2
14	169.0	344.0	170.0	344.0	2
15	170.0	344.0	210.0	344.0	2
16	210.0	344.0	227.0	344.0	3

15 SUBSURFACE boundary segments

Segment

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below
1	114.0	310.0	115.0	309.0	1
2	79.0	294.0	80.0	293.0	3
3	80.0	293.0	115.0	309.0	3
4	115.0	309.0	121.0	313.0	2
5	121.0	313.0	132.0	321.0	2
6	132.0	321.0	146.0	327.0	2

7	146.0	327.0	151.0	332.0	2
8	151.0	332.0	169.0	343.0	2
9	169.0	343.0	170.0	344.0	2
10	115.0	309.0	169.0	330.5	3
11	169.0	330.5	210.0	344.0	3
12	.0	275.0	80.0	293.0	4
13	80.0	293.0	117.0	304.5	4
14	117.0	304.5	169.0	328.0	4
15	169.0	328.0	227.0	344.0	4

ISOTROPIC Soil Parameters

4 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Constant (psf)	Water Surface No.
1	100.0	105.0	124.0	32.00	.000	.0	0
2	100.0	105.0	24.0	32.00	.000	.0	0
3	110.0	110.0	.0	35.00	.000	.0	0
4	125.0	125.0	.0	40.00	.000	.0	0

BOUNDARY LOADS

2 load(s) specified

Load No.	x-left (ft)	x-right (ft)	Intensity (psf)	Direction (deg)
1	95.0	125.0	15.0	.0
2	125.0	170.0	2.5	.0

NOTE - Intensity is specified as a uniformly distributed force acting on a HORIZONTALLY projected surface.

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 75.0 ft
and x = 125.0 ft

Each surface terminates between x = 130.0 ft
and x = 220.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

4.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

****

-- WARNING -- WARNING -- WARNING -- WARNING -- (# 48)

****

Negative effective stresses were calculated at the base of a slice.
This warning is usually reported for cases where slices have low self weight and a relatively high "c" shear strength parameter. In such cases, this effect can only be eliminated by reducing the "c" value.

****

USER SELECTED option for unrestricted values of strength

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface is specified by 18 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	112.93	309.55
2	116.84	310.42
3	120.70	311.46
4	124.51	312.66
5	128.27	314.03
6	131.96	315.57
7	135.59	317.26
8	139.14	319.11
9	142.60	321.11
10	145.97	323.26
11	149.25	325.55
12	152.42	327.99
13	155.49	330.56
14	158.44	333.26
15	161.27	336.09
16	163.97	339.04

17	166.54	342.10
18	167.49	343.33

**** Simplified BISHOP FOS = 1.198 ****

The following is a summary of the TEN most critical surfaces

Problem Description : Betty Bowen Prune/Remove and EC Mat

	FOS	Circle Center		Radius	Initial	Terminal	Resisting
	(BISHOP)	x-coord	y-coord		x-coord	x-coord	Moment
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft-lb)
1.	1.198	94.92	399.64	91.87	112.93	167.49	1.594E+06
2.	1.199	82.34	432.98	124.85	119.83	169.91	1.439E+06
3.	1.214	99.25	396.21	84.09	121.55	162.90	6.833E+05
4.	1.218	86.99	407.70	99.93	118.10	160.81	7.476E+05
5.	1.230	103.38	391.01	77.23	123.28	162.18	5.500E+05
6.	1.234	91.29	401.59	95.25	109.48	166.18	1.666E+06
7.	1.256	88.40	411.26	106.08	106.03	170.44	2.487E+06
8.	1.258	109.98	380.08	64.22	125.00	160.20	3.795E+05
9.	1.259	44.76	518.16	219.17	114.66	177.81	4.405E+06
10.	1.262	110.21	341.36	31.24	114.66	136.45	1.225E+05

* * * END OF FILE * * *

XSTABL File: J19601EQ   9-10-**   16:41

```
*****************************************
*              X S T A B L              *
*                                       *
*       Slope Stability Analysis        *
*              using the                *
*           Method of Slices            *
*                                       *
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*  Ver. 5.202                96 Ä 1692  *
*****************************************
```

Problem Description : Betty Bowen Prune/Remove & EC Mat EQ

SEGMENT BOUNDARY COORDINATES
----

16 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	286.0	22.0	288.0	3
2	22.0	288.0	55.0	290.0	3
3	55.0	290.0	74.0	292.0	3
4	74.0	292.0	79.0	294.0	3
5	79.0	294.0	95.0	302.0	1
6	95.0	302.0	114.0	310.0	1
7	114.0	310.0	117.0	312.0	2
8	117.0	312.0	120.0	314.0	2
9	120.0	314.0	131.0	322.0	2
10	131.0	322.0	144.0	328.0	2
11	144.0	328.0	150.0	334.0	2
12	150.0	334.0	160.0	340.0	2
13	160.0	340.0	169.0	344.0	2
14	169.0	344.0	170.0	344.0	2
15	170.0	344.0	210.0	344.0	2
16	210.0	344.0	227.0	344.0	3

15 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	114.0	310.0	115.0	309.0	1
2	79.0	294.0	80.0	293.0	3
3	80.0	293.0	115.0	309.0	3
4	115.0	309.0	121.0	313.0	2
5	121.0	313.0	132.0	321.0	2
6	132.0	321.0	146.0	327.0	2
7	146.0	327.0	151.0	332.0	2

8	151.0	332.0	169.0	343.0	2
9	169.0	343.0	170.0	344.0	2
10	115.0	309.0	169.0	330.5	3
11	169.0	330.5	210.0	344.0	3
12	.0	275.0	80.0	293.0	4
13	80.0	293.0	117.0	304.5	4
14	117.0	304.5	169.0	328.0	4
15	169.0	328.0	227.0	344.0	4

ISOTROPIC Soil Parameters

4 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	100.0	105.0	124.0	32.00	.000	.0	0
2	100.0	105.0	24.0	32.00	.000	.0	0
3	110.0	110.0	.0	35.00	.000	.0	0
4	125.0	125.0	.0	40.00	.000	.0	0

A horizontal earthquake loading coefficient
of .160 has been assigned

A vertical earthquake loading coefficient
of .000 has been assigned

BOUNDARY LOADS

2 load(s) specified

Load No.	x-left (ft)	x-right (ft)	Intensity (psf)	Direction (deg)
1	95.0	125.0	15.0	.0
2	125.0	170.0	2.5	.0

NOTE - Intensity is specified as a uniformly distributed
force acting on a HORIZONTALLY projected surface.

A critical failure surface searching method, using a random
technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced
along the ground surface between x = 75.0 ft
and x = 125.0 ft

Each surface terminates between x = 130.0 ft
and x = 220.0 ft

Unless further limitations were imposed, the minimum elevation
at which a surface extends is y = .0 ft

4.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined
within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

****
-- WARNING -- WARNING -- WARNING -- WARNING -- (# 48)

****
Negative effective stresses were calculated at the base of a
slice.
This warning is usually reported for cases where slices have low
self
weight and a relatively high "c" shear strength parameter. In
such
cases, this effect can only be eliminated by reducing the "c"
value.

****

USER SELECTED option for unrestricted values of strength

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface
is specified by 16 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	119.83	313.89
2	123.62	315.15
3	127.38	316.53
4	131.08	318.03
5	134.74	319.65
6	138.34	321.39
7	141.89	323.24

8	145.37	325.20
9	148.79	327.28
10	152.15	329.46
11	155.43	331.75
12	158.63	334.14
13	161.76	336.64
14	164.80	339.23
15	167.77	341.92
16	169.91	344.00

**** Simplified BISHOP FOS = .877 ****

The following is a summary of the TEN most critical surfaces

Problem Description : Betty Bowen Prune/Remove & EC Mat EQ

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	.877	82.34	432.98	124.85	119.83	169.91	1.323E+06
2.	.881	94.92	399.64	91.87	112.93	167.49	1.465E+06
3.	.895	99.25	396.21	84.09	121.55	162.90	6.290E+05
4.	.900	86.99	407.70	99.93	118.10	160.81	6.882E+05
5.	.904	44.76	518.16	219.17	114.66	177.81	4.065E+06
6.	.908	103.38	391.01	77.23	123.28	162.18	5.069E+05
7.	.911	91.29	401.59	95.25	109.48	166.18	1.536E+06
8.	.916	96.37	426.19	114.73	119.83	176.40	2.204E+06
9.	.920	65.37	487.21	182.88	116.38	179.10	3.752E+06
10.	.923	88.40	411.26	106.08	106.03	170.44	2.296E+06

* * * END OF FILE * * *

XSTABL File: J19602   9-10-**   16:42

```
******************************************
*              X S T A B L               *
*                                        *
*       Slope Stability Analysis         *
*              using the                 *
*           Method of Slices             *
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* Ver. 5.202                  96 Ä 1692  *
******************************************
```

Problem Description : Betty Bowen Final Vegetation

SEGMENT BOUNDARY COORDINATES
----

16 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	286.0	22.0	288.0	3
2	22.0	288.0	55.0	290.0	3
3	55.0	290.0	74.0	292.0	3
4	74.0	292.0	79.0	294.0	3
5	79.0	294.0	95.0	302.0	1
6	95.0	302.0	114.0	310.0	1
7	114.0	310.0	117.0	312.0	2
8	117.0	312.0	120.0	314.0	2
9	120.0	314.0	131.0	322.0	2
10	131.0	322.0	144.0	328.0	2
11	144.0	328.0	150.0	334.0	2
12	150.0	334.0	160.0	340.0	2
13	160.0	340.0	169.0	344.0	2
14	169.0	344.0	170.0	344.0	2
15	170.0	344.0	210.0	344.0	3
16	210.0	344.0	227.0	344.0	4

15 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	114.0	310.0	115.0	309.0	1
2	79.0	294.0	80.0	293.0	4
3	80.0	293.0	115.0	309.0	4
4	115.0	309.0	121.0	313.0	3
5	121.0	313.0	132.0	321.0	3

6	132.0	321.0	146.0	327.0	3
7	146.0	327.0	151.0	332.0	3
8	151.0	332.0	169.0	343.0	3
9	169.0	343.0	170.0	344.0	3
10	115.0	309.0	169.0	330.5	4
11	169.0	330.5	210.0	344.0	4
12	.0	275.0	80.0	293.0	5
13	80.0	293.0	117.0	304.5	5
14	117.0	304.5	169.0	328.0	5
15	169.0	328.0	227.0	344.0	5

ISOTROPIC Soil Parameters
----

5 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	100.0	105.0	124.0	32.00	.000	.0	0
2	100.0	105.0	74.0	32.00	.000	.0	0
3	100.0	105.0	24.0	32.00	.000	.0	0
4	110.0	110.0	.0	35.00	.000	.0	0
5	125.0	125.0	.0	40.00	.000	.0	0

BOUNDARY LOADS
----

2 load(s) specified

Load No.	x-left (ft)	x-right (ft)	Intensity (psf)	Direction (deg)
1	95.0	125.0	15.0	.0
2	125.0	170.0	2.5	.0

NOTE - Intensity is specified as a uniformly distributed force acting on a HORIZONTALLY projected surface.

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

```
  30 Surfaces initiate from each of  30 points equally spaced
along the ground surface between  x =     75.0 ft
                             and  x =    125.0 ft


Each surface terminates between   x =    130.0 ft
                            and   x =    220.0 ft


Unless further limitations were imposed, the minimum elevation
at which a surface extends is  y =       .0 ft


    4.0 ft line segments define each trial failure surface.

---------------------
ANGULAR RESTRICTIONS
---------------------

  The first segment of each failure surface will be inclined
  within the angular range defined by :

          Lower angular limit :=   -45.0 degrees
          Upper angular limit :=  (slope angle - 5.0) degrees

************************************************************************
          --  WARNING  --  WARNING  --  WARNING  --  WARNING  --  (# 48)

************************************************************************
      Negative effective stresses were calculated at the base of a
slice.
      This warning is usually reported for cases where slices have low
self
      weight and a relatively high "c" shear strength parameter.  In
such
      cases, this effect can only be eliminated by reducing the "c"
value.

************************************************************************

          ------------------------------------------------------------
          USER SELECTED option for unrestricted values of strength
          ------------------------------------------------------------

          Factors of safety have been calculated by the :

          * * * * *   SIMPLIFIED BISHOP METHOD   * * * * *

            The most critical circular failure surface
            is specified by 18 coordinate points

                 Point       x-surf       y-surf
                  No.         (ft)         (ft)

                   1         112.93       309.55
                   2         116.84       310.42
                   3         120.70       311.46
                   4         124.51       312.66
```

5	128.27	314.03
6	131.96	315.57
7	135.59	317.26
8	139.14	319.11
9	142.60	321.11
10	145.97	323.26
11	149.25	325.55
12	152.42	327.99
13	155.49	330.56
14	158.44	333.26
15	161.27	336.09
16	163.97	339.04
17	166.54	342.10
18	167.49	343.33

**** Simplified BISHOP FOS = 1.220 ****

The following is a summary of the TEN most critical surfaces

Problem Description : Betty Bowen Final Vegetation

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.220	94.92	399.64	91.87	112.93	167.49	1.623E+06
2.	1.234	82.34	432.98	124.85	119.83	169.91	1.481E+06
3.	1.250	91.29	401.59	95.25	109.48	166.18	1.687E+06
4.	1.256	88.40	411.26	106.08	106.03	170.44	2.487E+06
5.	1.276	76.09	436.08	133.92	100.86	173.34	3.611E+06
6.	1.278	44.76	518.16	219.17	114.66	177.81	4.472E+06
7.	1.281	96.37	426.19	114.73	119.83	176.40	2.406E+06
8.	1.291	99.25	396.21	84.09	121.55	162.90	7.266E+05
9.	1.293	68.10	449.14	149.41	95.69	174.25	4.431E+06
10.	1.301	65.37	487.21	182.88	116.38	179.10	4.106E+06

* * * END OF FILE * * *

XSTABL File: J19602EQ 9-10-** 16:43

```
 ******************************************
 *              X S T A B L               *
 *                                        *
 *        Slope Stability Analysis        *
 *             using the                  *
 *          Method of Slices              *
 *                                        *
 *        Copyright (C) 1992 - 98         *
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 *                                        *
 *  Ver. 5.202                96 Ä 1692   *
 ******************************************
```

Problem Description : Betty Bowen Final Vegetation w EQ

SEGMENT BOUNDARY COORDINATES

16 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	286.0	22.0	288.0	3
2	22.0	288.0	55.0	290.0	3
3	55.0	290.0	74.0	292.0	3
4	74.0	292.0	79.0	294.0	3
5	79.0	294.0	95.0	302.0	1
6	95.0	302.0	114.0	310.0	1
7	114.0	310.0	117.0	312.0	2
8	117.0	312.0	120.0	314.0	2
9	120.0	314.0	131.0	322.0	2
10	131.0	322.0	144.0	328.0	2
11	144.0	328.0	150.0	334.0	2
12	150.0	334.0	160.0	340.0	2
13	160.0	340.0	169.0	344.0	2
14	169.0	344.0	170.0	344.0	2
15	170.0	344.0	210.0	344.0	3
16	210.0	344.0	227.0	344.0	4

15 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	114.0	310.0	115.0	309.0	1
2	79.0	294.0	80.0	293.0	4
3	80.0	293.0	115.0	309.0	4
4	115.0	309.0	121.0	313.0	3
5	121.0	313.0	132.0	321.0	3
6	132.0	321.0	146.0	327.0	3
7	146.0	327.0	151.0	332.0	3

8	151.0	332.0	169.0	343.0	3
9	169.0	343.0	170.0	344.0	3
10	115.0	309.0	169.0	330.5	4
11	169.0	330.5	210.0	344.0	4
12	.0	275.0	80.0	293.0	5
13	80.0	293.0	117.0	304.5	5
14	117.0	304.5	169.0	328.0	5
15	169.0	328.0	227.0	344.0	5

ISOTROPIC Soil Parameters
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5 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Constant (psf)	Water Surface No.
1	100.0	105.0	124.0	32.00	.000	.0	0
2	100.0	105.0	74.0	32.00	.000	.0	0
3	100.0	105.0	24.0	32.00	.000	.0	0
4	110.0	110.0	.0	35.00	.000	.0	0
5	125.0	125.0	.0	40.00	.000	.0	0

A horizontal earthquake loading coefficient
of .160 has been assigned

A vertical earthquake loading coefficient
of .000 has been assigned

BOUNDARY LOADS
----

2 load(s) specified

Load No.	x-left (ft)	x-right (ft)	Intensity (psf)	Direction (deg)
1	95.0	125.0	15.0	.0
2	125.0	170.0	2.5	.0

NOTE - Intensity is specified as a uniformly distributed force acting on a HORIZONTALLY projected surface.

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced

along the ground surface between x = 75.0 ft
and x = 125.0 ft

Each surface terminates between x = 130.0 ft
and x = 220.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

4.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

****
-- WARNING -- WARNING -- WARNING -- WARNING -- (# 48)

****

Negative effective stresses were calculated at the base of a slice.
This warning is usually reported for cases where slices have low self
weight and a relatively high "c" shear strength parameter. In such
cases, this effect can only be eliminated by reducing the "c" value.

****

USER SELECTED option for unrestricted values of strength

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface is specified by 18 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	112.93	309.55
2	116.84	310.42
3	120.70	311.46
4	124.51	312.66
5	128.27	314.03
6	131.96	315.57
7	135.59	317.26
8	139.14	319.11

9	142.60	321.11
10	145.97	323.26
11	149.25	325.55
12	152.42	327.99
13	155.49	330.56
14	158.44	333.26
15	161.27	336.09
16	163.97	339.04
17	166.54	342.10
18	167.49	343.33

**** Simplified BISHOP FOS = .899 ****

The following is a summary of the TEN most critical surfaces

Problem Description : Betty Bowen Final Vegetation w EQ

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	.899	94.92	399.64	91.87	112.93	167.49	1.495E+06
2.	.906	82.34	432.98	124.85	119.83	169.91	1.366E+06
3.	.920	44.76	518.16	219.17	114.66	177.81	4.134E+06
4.	.923	88.40	411.26	106.08	106.03	170.44	2.296E+06
5.	.923	91.29	401.59	95.25	109.48	166.18	1.558E+06
6.	.926	96.37	426.19	114.73	119.83	176.40	2.228E+06
7.	.931	76.09	436.08	133.92	100.86	173.34	3.335E+06
8.	.932	65.37	487.21	182.88	116.38	179.10	3.802E+06
9.	.941	68.10	449.14	149.41	95.69	174.25	4.095E+06
10.	.951	86.55	441.06	134.13	112.93	179.12	3.693E+06

* * * END OF FILE * * *